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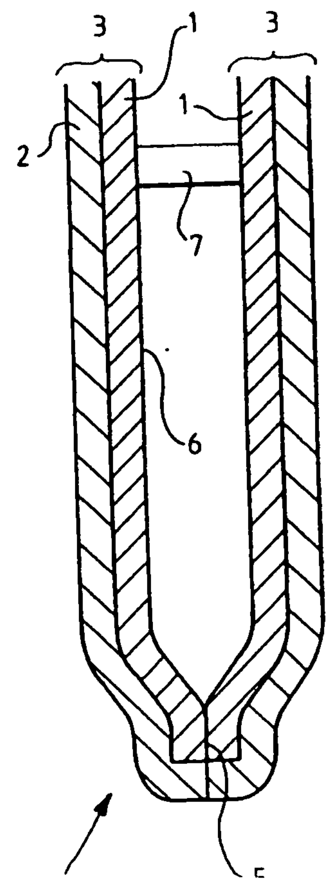
(57) Abstract

A heat exchanger, evaporator made from the heat exchanger, and method of utilization thereof, take advantage of the thin yet strong and good heat exchange surface that is provided by a metal-plastic laminate. A laminate is typically either one plastic layer and a metal layer, or two plastic layers sandwiching a metal layer between them. The laminate normally has a thickness of less than about 200 μm, for example the metal folio layer having a thickness of about 5-40 μm and the plastic layer a thickness of about 12-25 μm. Aluminum, cooper, and brass are good metals, while polyester and polyolefins are good plastics. Cellulose pulp mill plant liquid effluents may be passed in a falling film over the laminates to evaporate them, while steam is passed in the interior chamber between two laminates forming an evaporator.



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A HEAT EXCHANGER

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates to a heat exchanger, in which a new kind of an extremely thin, but yet strong heat exchange surface is utilized, and a method of evaporating an effluent from a cellulose pulp mill utilizing such a heat exchanger as a falling film evaporator.

Heat exchange devices, such as lamella heat exchangers, are conventionally manufactured of metal, e.g. of stainless steel. Lamellas have been manufactured of 1-1.5 mm thick metal plates to act as heat exchange elements, for example, in evaporators. Such a construction allows considerable pressure differences, but on the other hand it is heavy and rather expensive. If acid solutions are treated, the problem of corrosion arises, which again leads to the necessity of using special steel or titanium as the material of heat exchange surface, which considerably increases the price of the equipment.

Heat exchangers of light, corrosion-resistant and inexpensive construction have been manufactured by utilizing a thin plastic film as a heat exchange surface, whereby the heat exchange elements may, for example, be bag-like. Such heat exchangers are known, for example, from patent publications EP 34920 and DE 2511144. Plastics have, however, the disadvantage of poor heat conductivity and poor physical properties when in a thin film configuration.

EP 286400 discloses a plate-type heat exchanger in which the heat exchanger element is manufactured by combining two polymer panels of the thickness of 0.12-0.7 mm under heat and pressure to form flow channels therebetween. A first surface of one of the panels is coated with a [illegible] material at a desired channel pattern. A second

surface of the other panel facing the first surface is treated with a material such that, when the two surfaces are combined, it attaches to the first panel surface, except at the flow channels. The polymer used is preferably a polyamide, which may be coated by a metal film to improve its heat exchange properties.

According to the present invention, the above mentioned problems are eliminated or minimized. A heat exchanger applicable for different purposes is provided which is simple to manufacture, and the heat exchange surface of which conducts heat well, is thin and light, but yet at the same time strong.

A characteristic feature of the heat exchanger in accordance with the present invention is that the heat exchange surface of the heat exchange elements is formed of a laminate, which comprises at least two layers of different materials, a metal film layer and a plastics layer.

The laminate is manufactured preferably by combining a plastics layer to a thin metal folio layer. The heat exchange surface thus generated is light and the strength thereof is decisively better than that of a mere metal folio, and its heat transfer capabilities are greater than those of plastic. Also the manufacture of such a heat exchanger is less expensive than its metal counterpart.

According to a preferred embodiment a laminate comprises three layers, i.e. two plastics layers and a metal layer sandwiched therebetween.

The invention also contemplates use of the heat exchanger in a method of evaporating a liquid effluent (e.g. from a cellulose pulp mill) utilizing an evaporator surface comprising a metal-plastic laminate having a thickness of less than about 200 μm, comprising the step of passing [illegible] effluent in a falling film over the

metal-plastic laminate surface. This step may be further practiced by passing the pulp mill effluent in contact with the plastic layer of the metal-plastic laminate. Steam may pass interiorly of the laminate to provide heat for the evaporation of the liquid effluent.

The invention is described more in detail below, by way of example, with reference to the accompanying drawings illustrating some embodiments in accordance with the present invention, in which a lamella is formed by using a laminate as a heat exchange surface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURES 1 and 2 are fragmentary cross-sectional views of exemplary lamella according to the present invention; and

FIGURE 3 is a side schematic view illustrating use of the lamella of FIGURE 1 as an evaporator.

DETAILED DESCRIPTION OF THE DRAWINGS

It is possible, according to Fig. 1, to form a lamella, capable of use as a heat transfer element, from a laminate. The laminate 3 comprises a metal folio 1 and a plastics film 2. It is manufactured by means of methods known per se, for example, by gluing the metal folio 1 and the plastics film 2 to each other, or by extruding the plastics film 2 onto the metal folio 1. The lamella 4 is preferably manufactured by attaching two rectangular laminate strips 3 to each other along the opposite edges thereof, for example, by an adhesive joint 5 or the like. An opening is left on one side for the supply of the heat exchange medium and another opening on the opposite side for the discharge thereof. The plastics layer 2 in the laminate strip 3 may be longer than the metal layer 1, whereby the outer layers

of plastics 2 are also attached to each other by adhesive joint 5, as seen in Fig 1.

It is normally not necessary to protect the interior surface of the interior layer -- metal layer 1 in Fig. 1 (e.g. the steam space) -- of the lamella 4. However, if required the interior surface of metal layer 1 may be coated, as seen at 6 in Fig. 1, so that corrosion protection is provided for both the outer (by layer 2) and the inner surfaces of the metal folios 1. The protective coating 6 may comprise a film or paint.

No additional supporting structure within the lamella 4 is required for maintaining the laminates 3 separate, although an interior support 7 could be provided if necessary. The inner pressure of the lamella 4 is slightly greater than the pressure of the outside, whereby the laminate walls 3 are maintained at a distance from each other due to a pressure difference so that a passage for the heat exchange medium is formed between the walls. The laminates 3 may also be attached to each other by means of dot-like junction points (not shown) instead of spacers 7, for example by attachment with adhesive so as to limit the changes of form caused by the pressure of the heat exchange medium such as steam flowing between them.

In the embodiment in accordance with Fig. 2 a laminate 3' comprises three different layers, whereby a metal film layer 1' is set between two plastics layers 2'. The laminate strips forming a lamella 4' are attached to each other, as described in connection with Fig. 1, for example by a glue joint 5'.

The inner layer 1, 1' of the lamella illustrated in Figs. 1 and 2 is preferably the metal layer, and the outer layer 2, 2' the plastics layer. The metal layer 1, 1' may alternatively be on the outer surface of the lamella 4, 4'.

The metal layer 1, 1' of the laminate may contain any known metal or a compound or alloy thereof, such as aluminum, brass or copper. The most appropriate metal is believed to be aluminum due to its inexpensiveness. The thickness of the metal folio layer 1, 1' may be very small, but it must provide the laminate 3 with sufficient rigidity. Normally a thickness of layer 1, 1' less than about 100 μm is sufficient, but also thicker films (e.g. 200 μm) are possible and utilized, if the attaching method of the laminate layers and the construction of the heat exchanger require them. When aluminum is used usually a thickness of about 5-40 μm, preferably about 9-18 μm, is sufficient.

Applicable materials for the plastic layer 2, 2' may vary widely. Various plastics may be chosen, for example, according to the application purpose of the particular heat exchanger. The plastic material of the layer 2, 2' must provide a sufficient mechanical strength and corrosion resistance given the operation conditions of the heat exchanger. Preferably the thickness of each plastics film 2, 2' is less than about 100 μm. In most cases applicable plastics are polyester and polyolefins, such as polyethylene and polypropylene, whereby the thickness of a plastics layer is preferably about 12-25 μm.

It must be noted that the heat transfer efficiency of a laminate depends inversely directly on the thickness of the plastic layer 2, 2', whereas the good heat conductivity of the metal 1, 1' allows the free use of metal folios of different thicknesses without the heat transfer efficiency considerably decreasing. Thus the thickness of the plastic layer 2, 2' must be adjusted so that it provides sufficient strength to the laminate 3, 3', but is not excessively thick thus decreasing the conductivity of the laminate 3, 3'. The total thickness of the laminate 3, 3' is typically less than about 200 μm.

Heat exchange units 8 may be formed by means known per se from lamellas 4, 4' in accordance with the drawings to provide units of different sizes for different purposes. Lamellas 4, 4' may be attached one after another in a supporting frame to form a lamella cassette, as is known per se. A desired number of cassettes may be set within the same casing to form an evaporator.

Thus it is possible to manufacture a rather rigid, but yet flexible heat exchange lamella 4, which is corrosion resistant yet of sufficiently strong construction so as to be used as an evaporator, e.g. for evaporating waste liquids in a cellulose pulp mill. It operates, for example with respect to Fig. 3, as a falling film evaporator 8 in such a way that the condensing steam is supplied into the interior of the lamella 4 at inlet 10, and the liquid being evaporated (e.g. waste water) is caused to flow over the outer surface of the lamella 4, as indicated at 9 in Fig. 3. Vapour obtained in the evaporation is withdrawn from the space between the lamellas 4 at 11. The treated liquid (concentrate) is withdrawn at 12 and the condensate formed in the interior of the lamella is withdrawn at 13. The condensate 13 (clean water) is recycled back to the process.

By causing a pressure difference between the heat surfaces the condensing temperature is brought higher than the evaporation temperature. Thus it is possible to transfer the condensing temperature through the laminates 3 for evaporation (temperature difference T is a function of the pressure difference and the boiling point elevation of the liquid being evaporated).

The above description illustrates the use of a laminate 3 formed by combining at least two different materials for the manufacture of evaporators, but the use of the laminates is not limited for this. Instead it may be used as a heat

transfer surface also in many other applications, such as in effecting heat transfer between two liquids.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

WHAT IS CLAIMED IS:

1. A heat exchanger having a plate-like heat exchange element comprising a laminate of at least two layers of different materials, a metal folio layer, and a plastics layer.

2. A heat exchanger as recited in claim 1 wherein said laminate consists essentially of three layers, two plastics layers with a metal folio layer sandwiched therebetween.

3. A heat exchanger as recited in claim 1 wherein said metal-plastic laminate has a thickness of less than about 200 μm.

4. A heat exchanger as recited in claim 3 wherein said metal folio has a thickness of less than about 100 μm.

5. A heat exchanger as recited in claim 4 wherein said plastic layer has a thickness of less than about 100 μm.

6. A heat exchanger as recited in claim 3 wherein said metal folio is an aluminum folio.

7. A heat exchanger as recited in claim 6 wherein said aluminum folio has a thickness of about 5-40 μm.

8. A heat exchanger as recited in claim 6 wherein said aluminum folio has a thickness of about 9-18 μm.

9. A heat exchanger as recited in claim 3 wherein said metal folio is selected from the group consisting essentially of aluminum, brass, and copper.

10. A heat exchanger as recited in claim 9 wherein said plastic layer is selected from the group consisting essentially of polyester and polyolefins.

11. A heat exchanger as recited in claim 1 wherein said plastic layer is selected from the group consisting essentially of polyester and polyolefins.

12. A heat exchanger as recited in claim 11 wherein said plastics layer has a thickness of about 12-25 μm.

13. A heat exchanger as recited in claim 2 wherein each of said plastic layers has a thickness of less than about 100 μm.

14. A heat exchanger as recited in claim 13 wherein each of said plastic layers has a thickness of about 12-25 μm.

15. A heat exchanger as recited in claim 14 wherein said plastics layer has a thickness of about 12-25 μm.

16. A heat exchanger as recited in claim 15 wherein said metal folio has a thickness of about 5-40 μm.

17. A heat exchanger as recited in claim 1 wherein said metal folio has a thickness of about 5-40 μm.

18. A heat exchanger as recited in claim 1 wherein said metal folio layer and plastics layer are laminated together with adhesive.

19. An evaporator comprising first and second spaced plate-like heat exchange elements, each element comprising a laminate of a metal folio layer and a plastics layer, with a space for the transport of heat exchange fluid therebetween.

20. An evaporator as recited in claim 19 wherein the metal folio layer of each plate-like element is on the interior of said evaporator, bordering said interior passage.

21. An evaporator as recited in claim 19 further comprising

a third layer of plastics material, said metal folio layer sandwiched between said plastics layers.

22. An evaporator as recited in claim 19 wherein said laminate has a thickness of less than about 200 μm.

23. An evaporator as recited in claim 22 wherein said metal folio layer is selected from the group consisting essentially of aluminum, brass, and copper.

24. An evaporator as recited in claim 23 wherein said plastics layer is selected from the group consisting essentially of polyester and polyolefins.

25. An evaporator as recited in claim 24 wherein said metal folio has a thickness of about 5-40 μm, and said plastics layer has a thickness of about 12-25 μm.

26. An evaporator as recited in claim 20 further comprising an interior corrosion resistant coating on said metal folio.

27. A method of evaporating an effluent from a cellulose pulp mill utilizing an evaporator surface comprising a metal-plastic laminate having a thickness of less than about 200 μm, comprising the steps of: a) passing pulp mill liquid effluent in a falling film over the metal-plastic laminate surface.

28. A method as recited in claim 27 wherein said step a) is further practiced by passing the pulp mill effluent in contact with the plastic layer of the metal-plastic laminate.

29. A method as recited in claim 28 comprising the further step of passing steam into contact with the metal layer of the metal-plastic laminate.

30. A method as recited in claim 27 wherein said laminate consists essentially of three layers, two plastics layers with a metal folio layer sandwiched therebetween.

31. A method as recited in claim 30 wherein said step a) is further practiced by passing the pulp mill effluent in contact with the plastic layer of the metal-plastic laminate.

32. A method as recited in claim 31 comprising the further step of passing steam into contact with the metal layer of the metal-plastic laminate.

33. A method of evaporating a liquid effluent utilizing an evaporator surface comprising a metal-plastic laminate having a thickness of less than about 200 μm, comprising the step of passing the liquid effluent in a falling film over the metal plastic laminate.

34. A method as recited in claim 33 wherein said step is further practiced by passing the liquid effluent in contact with the plastic layer of the metal-plastic laminate.

FIG. 1

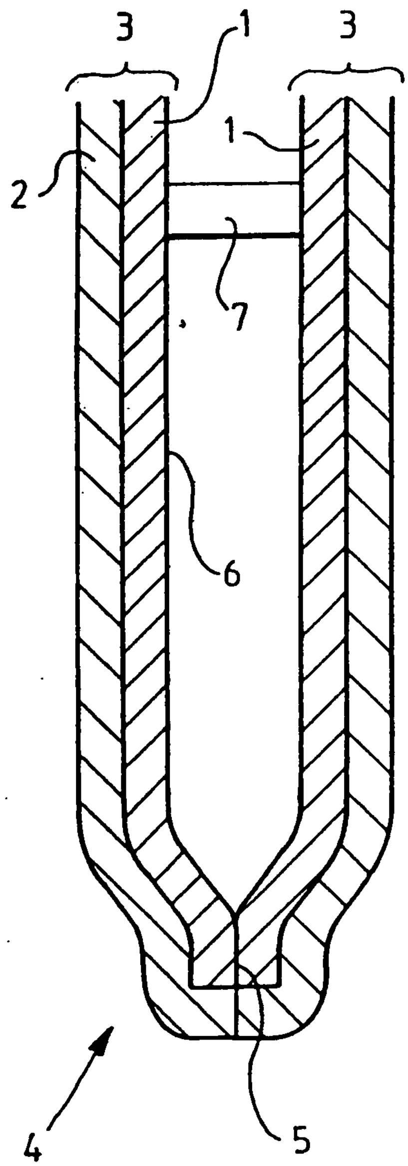
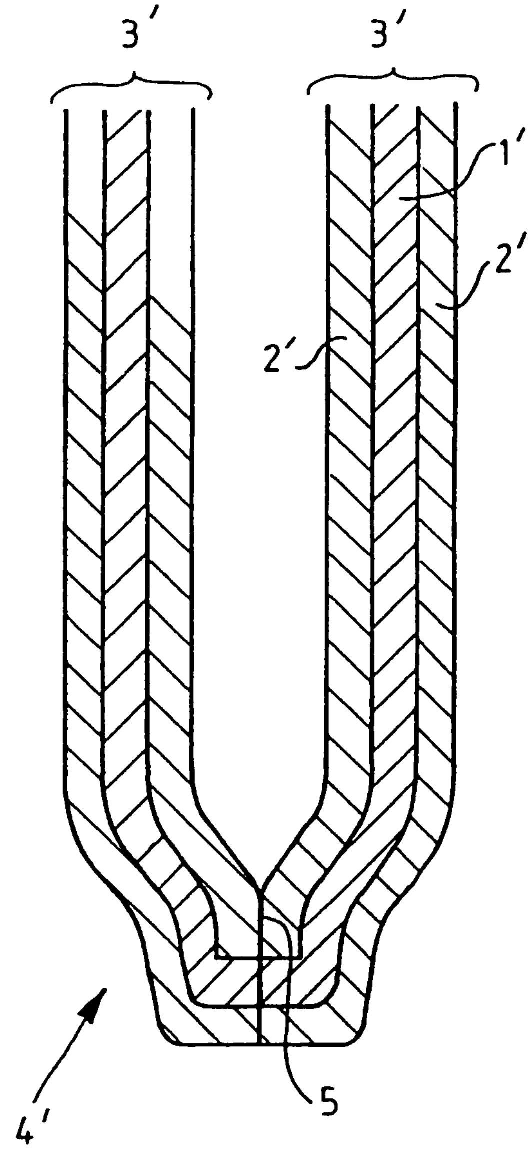
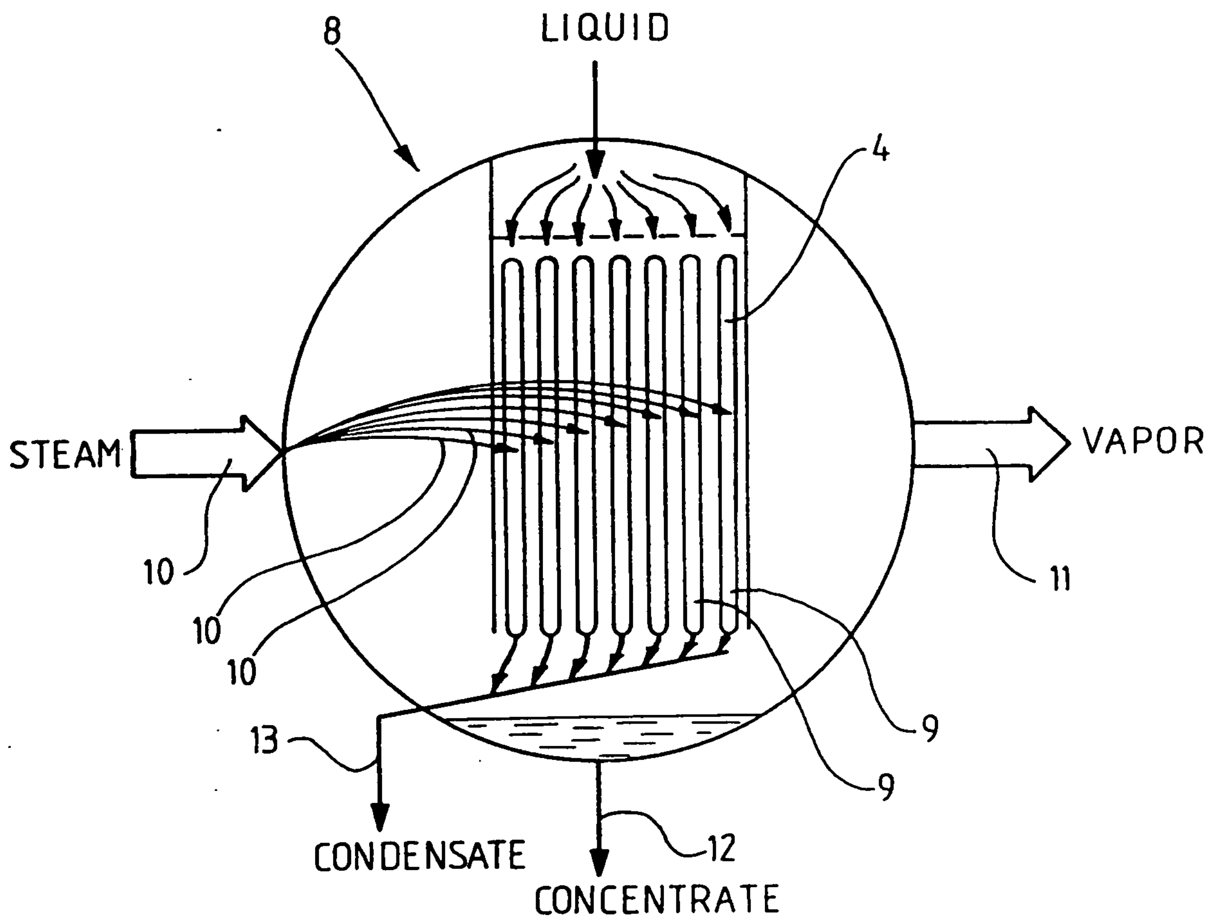


FIG. 2

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9
CONDENSATE
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CONCENTRATE

FIG. 3